APPENDIX

REPORT ON THE CAGE ACCIDENT WHICH OCCURRED AT EDGAR'S SHAFT, MYSORE GOLD MINE, ON THE 21ST AUGUST 1913.

An account of the accident is given in the Report of the Committee of Enquiry which is attached to this Report as Enclosure I.

In the Government Order No. 1407, dated 13th December 1913, on the Committee's Report it was directed that a further technical enquiry should be made dealing with the following questions:—

(1) The causes of the fracture of the adjusting link and whether the fracture was due to defective design or material or to improper use.

(2) The suitability of the clutch as a whole, of which the fractured link formed a part, for the purposes for which it is employed in connection with the winding of men in shafts.

(3) The efficiency of the brakes fitted to the Engine and whether it is desirable or possible to make them more powerful or more effective.

(4) Whether it is not possible to introduce safety catches for the cages in such shafts.

(5) What further precautions may be taken to minimize the possibility of such accidents.

The information which has been obtained during this enquiry is recorded below.

On several important points arising out of the accident Mr. J. A. Vaughan, Chief Inspector of Machinery, Union of South Africa, was consulted with the permission of the Government Mining Engineer and has kindly furnished his opinion. The Chief Engineers of the Mysore and Champion Reef Mines, the London Managers of the Mining Companies, the makers of the clutch and the makers of the winding engine have also been consulted on various points and their opinions are recorded below under appropriate headings.

I. THE CLUTCH.

The clutch, of which the fracture of the eye-bolt or link was the immediate cause of the accident, is of the friction-band type. A sketch of this clutch is shown in Fig. 1 (Plate I) in which C is the steel friction-band lined with blocks of wood W. This band grips a steel ring R which is attached to the side of the reel on which the flat winding rope is wound. The arrows show the direction of rotation of the reel and the travel of the rope for a descending cage as at the time of the accident.

The engine shaft S carries a heavy boss B, securely keyed to it, which is expanded into a circular disc D the periphery of which carries a number of rollers which prevent the band C from springing too far away from the ring R when the clutch is released.

The band C is held at one end by the eye-bolt E which is connected by a pin to a support A firmly bolted to the disc D.

The other end of C is connected to a bent lever L the fulcrum of which is fixed to the disc D and which is actuated by a toggle T pivoted to a slip ring. This slip ring can be forced to and fro along the boss B by means of a hand wheel, screw and train of levers. When the slip ring is forced towards the reel, the toggle T is pushed into a more erect position thereby raising the end of the lever L and tightening the band C. The nuts on E are adjusted so that the band C is tight on R when the toggle T has an inclination of 77° from the horizontal. The action of the clutch is obvious. When the band C is tightened so that there is no slipping,

the band and the ring R must move together as one piece and consequently the reel and the engine shaft must move together or, in other words, the reel is made fast to the engine shaft and moves with it. When the band C is loosened by moving the slip ring outwards, the ring R and the reel to which it is attached is freed from contact with the band C and the reel and engine shaft can therefore revolve independently of one another.

The connection between the reel and the engine shaft depends therefore on the friction band being made sufficiently tight and upon its remaining so.

It is obvious that it will fail to remain tight if any portion of the band itself or if the lever or eye-bolt should break in which case the reel would become entirely detached from the engine and capable of revolving freely without any control except such as is afforded by brakes attached to the reel itself. In the present instance, the eye-bolt E snapped in two while winding was going on and although the engine was promptly stopped the reel continued to revolve, and the cage attached to the rope continued to descend in spite of the application of the brakes acting on the periphery of the reel itself.

The first point for investigation is the strength of the eye-bolt and the stresses to which it is subjected. Fig. 2 shows an enlarged view of the broken bolt; it will be seen that the fracture occurred close to the eye at one of the V shaped threads. It is a forging of mild steel, the bolt itself being 3⅛th inches in diameter at the bottom of the threads. The breaking weight at the point of fracture was estimated at 230 tons. An actual test of the corresponding eye-bolt on the north reel clutch gave a breaking stress of 33·11 tons or a total of 254 tons for a bolt 3⅛th inches in diameter.

This has to withstand the pull of the clutch band when it is tightened up as well as the stresses incidental to driving the load the greater part of which is effected through this eye-bolt as the connecting link between the reel and the engine shaft. The work is, of course, shared by the lever at the other end of the clutch band, but as this is less rigid than the former it will not participate so largely in kinetic shocks.

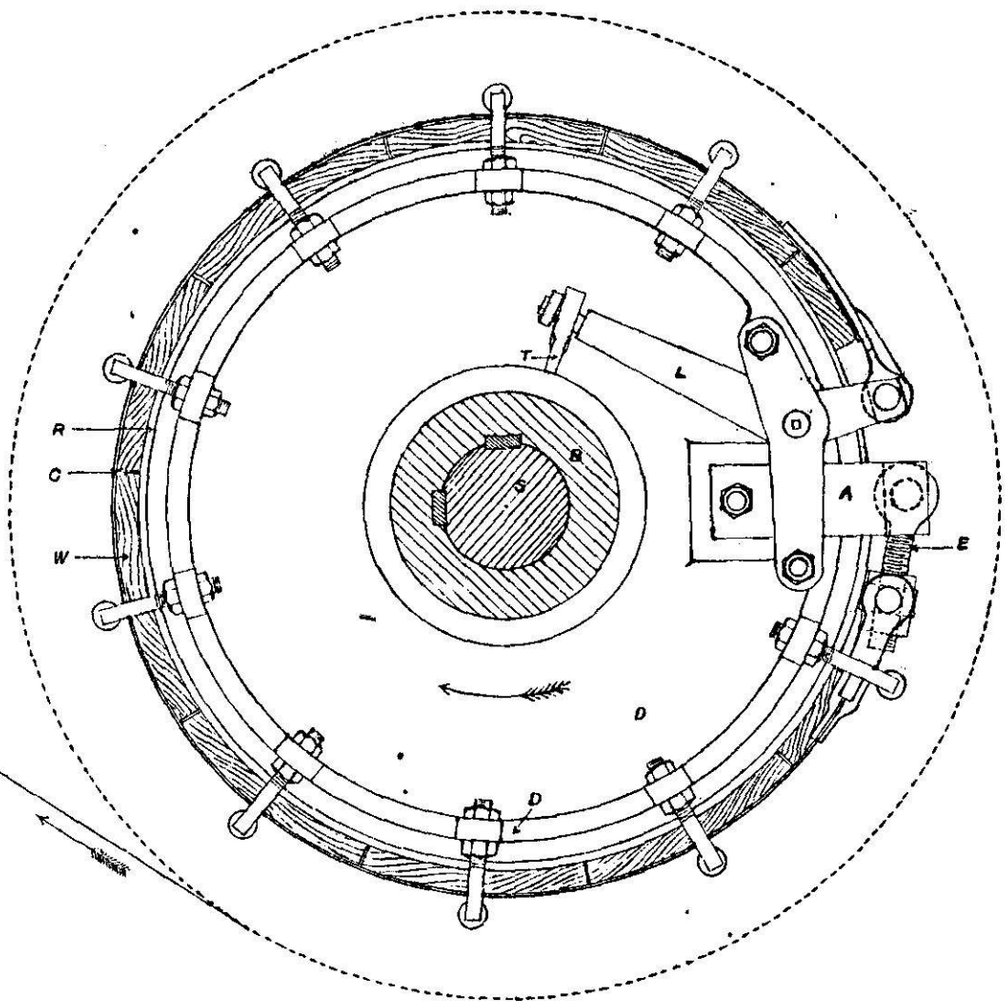
The pull of the clutch band is determined by the efforts of two coolies on a hand wheel and screw acting on the toggle through a system of levers. Mr. Paterson, Chief Engineer of the Mysore Mine, estimates that the pull thus put on the clutch band is 58·5 tons. Mr. Vaughan estimates the pull at about 65 tons (2,240 lbs.) allowing an efficiency of 32·6 per cent for the screw based on a co-efficient of friction of 0·15.

Taking Mr. Vaughan's figures as being the larger, this is equivalent to a tensile stress of 8·5 tons on the eye-bolt if the total pull on the clutch band is transmitted to the eye-bolt.

Mr. Vaughan points out that in addition to direct pull the eye-bolt may be subjected to bending stresses owing to heavy friction on the pin passing through the eye and he calculates that these may give rise to an additional stress of about 7·6 (long) tons on the outer fibres of the bolt and that this added to the pull on the band may raise the total stress to somewhere near the ultimate limit.

I am not clear myself as to how these bending stresses come into operation, but accepting Mr. Vaughan's figures the total stress on the outer fibres would be some 16 tons while according to the test made on the other eye-bolt the tensile strength of the steel was about 33 tons. This would give a factor of safety of 2, which, though it may be too low for safe working, indicates a considerable reserve of strength under the conditions suggested. It appears to me, however, that we are not entitled to assume that the pull of the lever is fully transmitted through the clutch band to the eye-bolt on account of the friction between the wood blocks of the band and the steel ring R. It is impossible to fully tighten the clutch with the hand wheel and after this has been screwed home the clutch band slips a little as soon as the load is taken up after which the hand wheel can be screwed down a little farther. During this slipping, a proportion of the pull of the lever L on the band is transmitted to the eye-bolt, but I do not think that even then the pull on the eye-bolt rises to anything near the pull on the other end of the band.

In connection with this point, the following test was made with the corresponding eye-bolt on the north drum of the engine, the eye-bolt in question having been in use for the same period as the bolt which broke.



Scale ½" — 1'

Fig.1

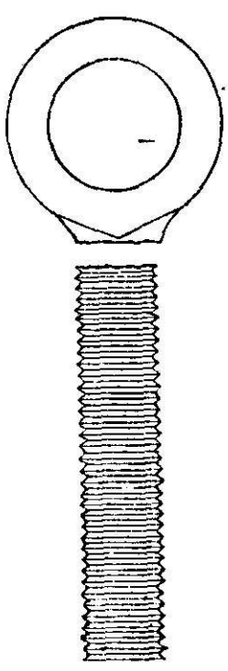


Fig.2

Fig. 4
(NATURAL SIZE)

Scale 1½" — 1'

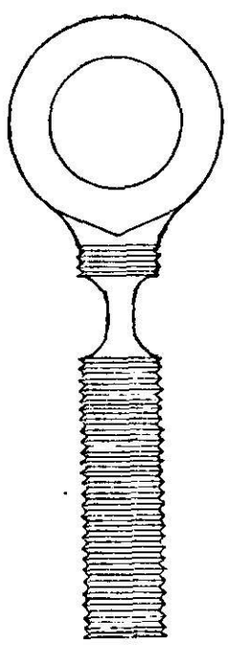


Fig.3

A portion of the eye-bolt on the north drum was turned down—as shown in Fig. 3—in order to weaken it.

The bolt was then replaced, the clutch band fully tightened with the toggle at its working position of 77°. Two men at the hand wheel tightened it and jerked it as far as they could in the endeavour to break the weakened bolt. The whole rope was housed on the reel and steam turned on full and as soon as the reel was revolving at 60 revolutions the brakes were thrown on suddenly (acting through a cataract) and notwithstanding that the steam remained on the reel was brought to rest every time within some 3 revolutions, practically the whole of the retardation taking place within the last half revolution. This was a fairly severe test as the weakened eye-bolt had to stand not only the strain of the clutch band but the strain due to rapid retardation of the reel against steam. Mr. Vaughan suggests that steam may not have been full on as it would not take full steam to run the reel at 60 revolutions. I am unable to say definitely that this was the case but, at any rate, we may take it that the eye-bolt was subjected to a considerable strain in addition to that due to the tightening of the band by forcible urging of the hand wheel.

In each test, the engine was run backwards and forwards several times and the brakes applied.

The results of the tests were as follows:—

1st test	...	Eye-bolt turned down to 2″ diameter	...	No effect produced.
2nd test	...	Eye-bolt turned down to $1\frac{3}{4}$″ diameter	...	No effect produced.
3rd test	...	Eye-bolt turned down to $1\frac{1}{2}$″ diameter	...	After test the reduced part showed a longitudinal crack.
4th test	...	Eye-bolt turned down to $1\frac{3}{8}$″ diameter	...	A small portion of metal alongside the crack came out.
5th test	...	Eye-bolt turned down to $1\frac{1}{4}$″ diameter.		

The crack disappeared entirely; after the test the diameter of the reduced portion was found to be $1\frac{1}{8}$″ with an elongation of $\frac{5}{16}$″ and the crack opened out considerably. Even then we were unable to break the test piece.

The eye-bolt was then removed and broken by a direct pull in a testing machine. It broke at 33·11 tons. In the centre of the test piece there was found to be a flaw or cavity about 5 inches in length and of section shown in Figure 4. Allowing for this, the area of the test piece was just about 1 square inch which gives a breaking stress for the metal of 33·11 tons. The fracture was finely granular or crystalline, very similar to the fracture of the broken eye-bolt of the south reel.

This test appears to afford conclusive evidence that the strain which can be put upon the eye-bolt by tightening the clutch is only a fraction of that put upon the other end of the clutch band by the bent lever, even when the hand wheel is violently jerked which is not the case in ordinary working.

Further, the strains due to sudden retardation by the brakes against steam were probably as great as those due to acceleration of the load during actual working and yet these strains combined with the pull of the clutch band did not amount to 33 tons as against the 254 tons estimated breaking strength of the original eye-bolt.

It would seem therefore that under the conditions of the accident the eye-bolt would have had a factor of safety of at least 7 or 8 and as there was no flaw in the eye-bolt which broke, nor signs of deterioration, the fact of its failure appears to me to be quite unexplained.

Although there is no evidence to show that anything untoward or exceptional occurred at the time of the accident, it is worth while to consider whether any conditions might occur in which the eye-bolt would be subjected to much more violent stresses than those which have been indicated as probable during the progress of ordinary work.

So long as the clutch band remains tight without any slipping it does not seem possible for the stress on the eye-bolt to increase very much above that indicated by the abovementioned experiments even if we allow for sudden acceleration due to bad driving. Mr. Vaughan mentions a case in which the eye-bolt had been made so tight on its bearing (by means of adjusting nuts) as to become practically a fixture with the result that bending stresses became sufficiently intense to

cause fracture. In the Mysore case, there are no such adjusting nuts and the bending stresses can be only those due to friction in the bearing and with the comparatively low total pull on the bolt, as indicated by the experimental tests, these stresses will not be very important.

There is however one case, and so far as I can see only one, in which the pull on the eye-bolt might become very largely increased. It will be remembered that immediately before the accident the south clutch had been thrown out and the north cage raised to another level. Supposing that before commencing the downward trip the south clutch had not been put on sufficiently tightly to prevent slipping under the pull of the descending cage, the following events might occur.

Steam would be put on to raise the north cage and the brakes taken off both reels. In a revolution or two it would be noticed that the south reel was gaining undue velocity and slipping through the clutch. Steam would then be cut off and the brakes applied in which case the north cage and the engine shaft would come to rest within a revolution or so but the south cage would continue to descend even against the brakes which, as will be shown later and as demonstrated by the accident itself, were not sufficiently powerful to arrest the descending cage with the reel unclutched. As soon as this was realized it is only natural to suppose that the next act would be to hurriedly tighten the hand wheel with the result that the clutch band, now stationary along with the engine shaft, would bite fiercely on the revolving ring of the reel with the result that an enormous shock would be given to the eye-bolt and the end of the clutch band attached to it owing to the momentum of the rapidly moving cage rope and reel. It is evident that such a shock would give rise to stresses far in excess of any that could be produced during working with a tight clutch and might easily exceed the ultimate strength of the eye-bolt.

Taking the ultimate strength of the clutch band at 187 tons, as calculated, and that of the eye-bolt at 254 tons, it may be asked why the latter should give way and not the former. We have of course the fact that such was the case and if we allow that the material of the eye-bolt was in good condition and unflawed we have to account for its failure in preference to the failure of the clutch band.

Taking Mr. Vaughan's figures in which the pull on the eye-bolt was assumed at 65 tons, giving a stress of 8·5 tons due to direct pull and an additional 7·6 tons on the upper fibres due to bending or a total of 16·1 tons on those fibres, it will be seen that if the total pull is about doubled the stress on the upper fibres will rise to the ultimate limit of 33 tons. Under these conditions, a total pull of 140 tons or so would be sufficient to fracture the eye-bolt while some 187 tons or so would be required to break the clutch band.

In this way, it seems possible to account for a sudden pull on the eye-bolt which would be very much in excess of anything obtainable under normal conditions of working and of sufficient magnitude to fracture a sound eye-bolt as well as explaining why the bolt should have given way in preference to the weaker clutch band.

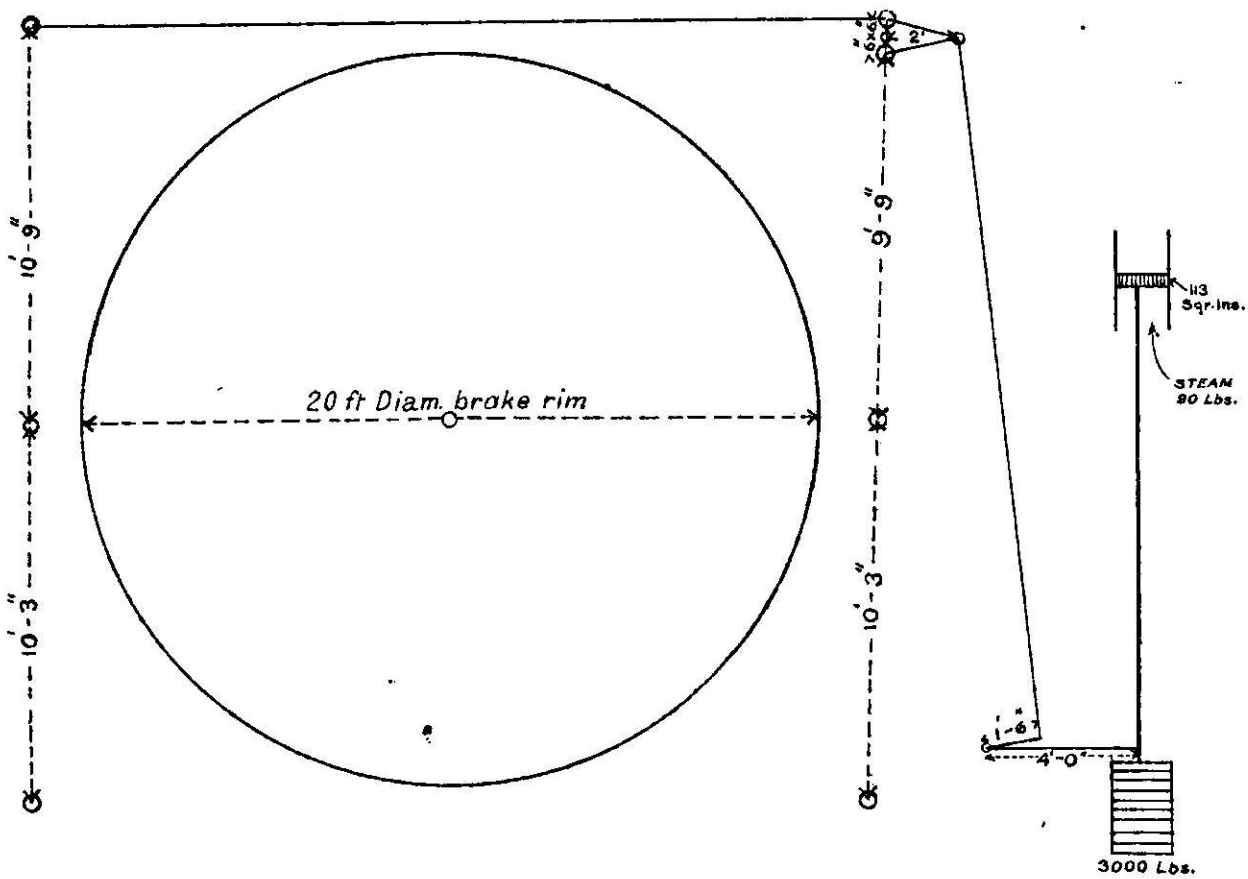
This suggested explanation is put forward in the face of the difficulty of explaining the fracture of the bolt under normal conditions of work although no evidence has been forthcoming to support it and the statements of those present are opposed to any suggestion of the clutch having been insufficiently tightened. Apart from this academic suggestion which I have put forward, the fracture of the eye-bolt appears to me to remain unexplained.

Suitability of the Clutch for Winding Men.—In view of the serious nature of this accident, the question of the suitability of this form of clutch for winding men naturally arises. The eye-bolt appears to have been suitably designed and of good material and ample strength for all normal conditions and yet it failed and caused great loss of life. On a similar clutch in the Champion Reef Mine, the bent lever which tightens the clutch band broke owing to a flaw in the casting. This released the drum, but the skip was stopped by the brakes. On another occasion, the eye plate by which the clutch band is attached to the bent lever developed a crack which was detected and the plate replaced by another which again developed a crack. Fortunately, these cracks were detected before the plate fractured completely.

Plate II.

DIAGRAM OF

EDGAR'S REEL-ENGINE BRAKE.



Mr. Vaughan to whom these points were submitted is not of opinion that the clutch should be prohibited though he would prefer a multiple tooth clutch for deep level winding.

To reduce the chance of accident with the friction clutch, he suggests the following steps:—

(*a*) Bolt up one clutch, and only use one free drum or reel.

(*b*) Make the thread of the eye-bolt round instead of V shaped.

(*c*) Turn off all thread from the eye-bolt except that which is required; the "Edgar's" bolt, threaded right up to the head, was not the best form.

(*d*) Alter the leverage, so that the maximum possible pull on the eye-bolt is reduced to only a little more than is necessary to prevent the clutch slipping *viz.*, about 25 tons, at a co-efficient of 0·5. In this connection, it may be advisable to line the band with "Ferrodo", which material certainly increases the co-efficient of standing friction.

(*e*) Regularly anneal the eye-bolt.

The Chief Engineers of the Mysore and Champion Reef Mines point to the large number of trips which have been made without accident and to the great convenience of the clutch where many levels are being worked.

The makers of the clutch suggest very similar precautions to those suggested by Mr. Vaughan with the addition that the parts subjected to strain and shock should be made of the best iron instead of steel and spares kept in stock to permit of regular annealing.

With attention to the precautions suggested there is little doubt that the security of the clutch would be much enhanced, but nevertheless I am not in favour of these clutches being retained in cases where men are wound and the moving masses so large as to require great braking power in case of a failure. My objections rest on the ground that the clutch mechanism involves a number of single links or parts, such as the clutch band, the eye-bolt, the bent lever and the toggle lever, the failure of any one of which will completely release the reel or drum and may throw an amount of work on the brakes which they may be unable to take care of in time to avert an accident. On this account, it has been decided to do away with these clutches as soon as possible at Mysore and Champion Reef in cases where men are being wound and to replace them with special multiple tooth clutches in which provision has been made for a fine adjustment of the position of the cage at any level which is not usually possible in toothed clutches.

Temporary Measures.—The new clutches will take some time to procure and in the meantime the clutches of the Edgar's Shaft Engine have been securely bolted to the reels so that they are now entirely out of commission. At Carmichael's Shaft, Champion Reef Mine, one of the clutches has been bolted up and the other is very carefully watched. At this shaft, the brakes have already been proved sufficiently powerful to arrest a runaway load.

II. The Brakes.

These are of the ordinary post type lined with wood and acting on the brake-path attached to the periphery of the reel which has a diameter of 20 feet.

The brake is actuated by a weight of 3,000 lbs. acting at the end of a train of levers, the weight being taken off as required by steam. Plate II illustrates the action of the brake diagrammatically.

The accident shows clearly that the brake was inadequate to bring a runaway cage to rest and on this point the following remarks by Mr. Vaughan show that that result is in accordance with the results of mathematical investigation.

> "Taking the total load on the reel as 15,640 lbs. at 9 feet 9 inches radius (reduced from 10 feet, as some rope has been unwound) the moment of 154,830 lbs. ft. is arrived at which gives a pull at the brake path—10 feet radius—of 15,483 lbs. The total brake pressure works out at 63,100 lbs., and, applying the co-efficient of 0·2, the effective pressure becomes 12,620 lbs.—considerably less than 15,483 lbs. The load would, there-

fore, be subject to acceleration, and the velocity of 1,200 feet would soon be much exceeded, especially so as the brakes could not be applied *immediately*, and one second delay means a great deal in this connection.

"During the descent of the cage the descending weight increased, but this increase would be more than compensated for by the decrease in radius of the winding reel, so that gradually the brakes would become more effective, except for the probable diminution in co-efficient of friction due to the charring of the wood blocks. It appears from the evidence that the final velocity was nothing like what would have been due to anything like 'free fall'.

"From the point of view of safety, the brake is the most important unit of the winding equipment, but it is quite certain that in the past the designers of winding plant have figured on a co-efficient of friction largely in excess of that which actually obtains when a fair velocity is attained."

This opinion was placed before the Superintendent of the Mine who referred it to the London Managers of the Company and they have furnished a complete investigation of the braking conditions. The calculations in connection with this investigation are given in Enclosure II and are based on the determination of the total braking torque necessary to prevent acceleration (static torque) and to bring the reel and suspended loads to rest in say 10 seconds (dynamic torque).

For calculation purposes it is assumed, as the most serious condition, that a broken clutch occurs with a loaded cage travelling downwards in the shaft and that the brake is applied when the reel is moving at 60 revolutions per minute—corresponding to the maximum speed of the engine. The point at which the most unfavourable conditions occur can best be determined by means of torque diagrams, since the static torque first increases and afterwards decreases with the depth of the cage in the shaft whereas the dynamic torque due to the moment of inertia of the moving masses decreases with depth.

The results of the investigation are stated as follows:—

"From the calculations and combined diagram of static and dynamic torques, it appears that the most unfavourable braking position for a clutch accident would be at a vertical depth of nearly 1,700 ft. with brakes applied to a cage of men descending at about 3,000 ft. p. min.

"At this point, the combined torque required to prevent acceleration and to bring the reel and cage to rest in 10 seconds is a maximum at about 253,500 ft. lbs. so that with a co-efficient of friction of 0·2 a braking pressure of 126,750 lbs. is required at 10 ft. radius of brake path.

"The present weight of 3,000 lbs. on the end of the brake lever produces a braking pressure of only 64,000 lbs. through the existing system of levers, and it is evident that this is quite insufficient to meet the conditions outlined above; in fact the weight should be doubled to 6,000 lbs.

"We understand that the makers originally supplied a double acting brake engine, with a view to using steam to assist the dead weight in case of emergency.

"With 120 lbs. per sq. inch steam pressure acting on a piston area of 113 sq. inches, the emergency braking effect would have been 13,550 lbs. in addition to the dead weight of 3,000 lbs. for normal manipulation. This would give a total braking pressure of 353,500 lbs. at 10 feet radius of brake path which is excessive, firstly because the brake gear parts are not strong enough to stand the very heavy pull and secondly the application of so large a torque might set up dangerous stresses in the rope.

"It seems probable that the Engineers on the Mine may for this reason have discarded the emergency steam braking arrangements provided."

From information supplied by the Chief Engineer of the Mysore Mine, I find that at first direct steam was used on the piston of the brake engine at a pressure of 60 lbs. Owing to sticking of the D valves, the operation of the brake was found

to be difficult and irregular and the brake came into operation either late or so suddenly that the rope showed signs of surging and the effect was considered to be dangerous. In view of this, the D valves were replaced by piston valves similar to those employed on the skip engine which have always given satisfactory results. In this type, the steam is used only to lift the weights and release the brakes, the braking effect being accomplished by the dead weight only.

The Chief Engineer states that in his opinion the weight of 3,000 lbs. was considered to be ample but that the severe conditions which would arise from a failure of the clutch were not anticipated or provided for.

There is no doubt that a weight of 3,000 lbs. is sufficient for normal working and that with it the static test required in the Transvaal *viz.*, that the brake should be capable of holding up the cage when loaded to double its capacity with no more slipping than one foot, was duly provided for.

In this connection, I had a further test of this brake made after the accident, with the charred wood blocks still on just as at the time of the accident, with the following result.

The cage was loaded with 5 tons of bricks and lowered to the 7th level. It was then raised 6 feet and held by the brake. The clutch was then released and the reel slipped half an inch through the brakes. The brake therefore fully complied with the required test even after charring of the blocks. It may be mentioned however that it has been the custom at this mine to drill holes in the brake blocks and fill them with rosin and sand with the view of increasing the friction and that in consequence of this the co-efficient of friction may have been in excess of 0·2 and the conditions less unfavourable than shown by the above calculation.

The final conclusions on the question of the brake may be stated as follows:—

(*a*) The brake was inadequate to stop the runaway cage before it reached the bottom of the shaft as proved by the accident.

(*b*) The theoretical investigation shows that the brake is inadequate to bring the cage to rest in 10 seconds after the release of the clutch if travelling at its maximum speed of about 3,000 feet per minute.

(*c*) The static test which provides that the brake shall be capable of holding up the cage when loaded with double its maximum working load is insufficient provision for kinetic conditions which may arise in the event of the reel becoming free.

(*d*) It is difficult or impossible to insist on "runaway" tests the failure of which would probably wreck the shaft, but it seems necessary to insist that theoretical investigations should be made in the case of all large winding engines and provision made for the most serious emergencies within reasonable limits.

Steps taken to increase the Power of the Brakes.—Some assumption is necessary as to the brake power which should be provided for a winding engine of this character. The assumptions on which the calculations recorded above have been based appear to me to be reasonable and adequate. These are that the brake should be capable of bringing a fully loaded cage descending at a velocity of 3,000 feet per minute to rest within 10 seconds the drum or reel being free of the engine shaft. In the case of the Edgar's Engine this means increasing the weight which actuates the brake from 3,000 to 6,000 lbs. Had the larger weight been in operation at the time of the accident the descent of the cage would probably have been arrested before it reached the bottom of the shaft and loss of life consequently averted. Under some conditions, even a weight of 6,000 lbs. might prove insufficient to bring the cage to rest in time to avert a catastrophe, but it is not possible to go on increasing the weight indefinitely without running into danger in other directions. For instance, there is the danger of breaking some of the tie rods or other parts of the brake mechanism or of putting dangerous strains on the rope and its attachments or on the reel itself or other parts of the winding engine. Admitting that the weight of 3,000 lbs. was quite inadequate to arrest the cage under the comparatively mild conditions under which the accident is stated to have occurred, it becomes necessary to decide upon increasing this weight so as to provide sufficient power to take care of even more severe conditions within reasonable limits. It appears to me that the limits provided for by a weight of 6,000 lbs. are reasonably severe and might be adopted.

An investigation has been made as to the capability of the brake parts to withstand the action of such a weight and they are considered to be equal to the task. The Chief Engineer of the Mine has however expressed some doubt as to the reel itself, which carries the brake path, being capable of withstanding the strains which the increased pressure may put upon it and to guard against these the reel has been very considerably strengthened by the addition of a number of radial arms.

The dead weight has now been increased to 4,500 lbs. and the brake is working smoothly and satisfactorily and preparations have been made for increasing the weight to the full 6,000 lbs. before clutches are again installed.

It is of course necessary to state that at the present the clutches are bolted up and therefore out of commission and that the severe conditions on which the calculated weight of 6,000 lbs. has been arrived at are at present practically impossible of realization. It is desirable however to increase the weight gradually up to the maximum of 6,000 lbs. to permit of experience being obtained with the use of the more powerful brakes before the new clutches are installed.

III. Safety Catches.

Various forms of safety catches have been devised and used for the purpose of arresting the descent of a cage in the event of the rope breaking or becoming detached.

In the case of the Edgar's Shaft accident the rope did not break, but remained attached to the reel under considerable tension. Mr. Vaughan expresses the following opinion on this point:—

> "I would premise that no safety catch with which I am acquainted would have been of any likely use in the accident at the Edgar's Shaft.
>
> "The 'Schewder' safety catch is not being used in the Transvaal. The Mines Department has not insisted on the use of safety catches where steel guides are installed, and this may be one of the great reasons. Consulting Engineers have certainly not favoured the use of this device and the inventor himself, so far as I am aware, has ceased to push it".

This opinion agrees with the opinions of Consulting Engineers generally and the practice at Edgar's Shaft of running the cages on steel guides without safety catches is in agreement with the existing practice elsewhere.

I have suggested the possibility of substituting large wooden guides backed with channel iron for steel guides and applying safety catches of the "Undeutsch" type to them. It would be possible in this way to use this type of catch which has been shown to possess great merit when applied to wooden guides, but the advisability of substituting wooden for steel guides is certainly problematical. The suggestion has however been placed before the Mining Board for consideration and will be discussed further.

IV. Conclusions.

(1) The failure of the eye-bolt of the clutch, which was the immediate cause of the accident, has not been in my opinion satisfactorily accounted for. The bolt appears to have been of excellent material and amply strong for the work expected of it. The fact that it failed suggests that it was subjected to some unusual and exceptionally violent shock as to the nature of which no evidence has been forthcoming.

(2) In cases where these clutches are retained the special precautions indicated by Mr. Vaughan and by the makers in regard to the substitution of the best iron for steel, the provision of spare parts and regular annealing should be attended to.

(3) The fact that the integrity of the clutch depends on a number of single links or parts, the failure of any one of which releases the clutch, renders the advisability of using this form of clutch for winding men somewhat questionable. On the Kolar Field, it has been decided to replace these clutches by others of the multiple tooth type in cases where men are being raised and lowered.

(4) The brakes in use on the Edgar's Engine were inadequate to bring the freely revolving reel and its attached cage to rest in time to avert a catastrophe. The prescribed static test was fully complied with but is obviously insufficient to guard against accident under the kinetic conditions involved in the event of a runaway reel. The possibility of the runaway owing to release of the clutch does not appear to have been contemplated by the Engineers of the Mine and sufficient braking power to deal with such an emergency was not provided for.

It is very desirable that the results of this investigation should be published and that the Superintendents of Mines should be requested to have the case of each winding engine specially investigated with a view to providing sufficent braking power to deal with exceptional contingencies within reasonable limits. The calculations for the Edgar's Engine, given above, are based on assumptions which may be regarded as reasonable and adequate, but which may possibly require some further technical consideration.

I am of opinion that the failure to provide the amount of brake power which has now been shown to be desirable for the Edgar's Engine was not due to any carelessness or negligence, but mainly to failure to recognize the possibility of certain exceptional and unexpected conditions arising. The very serious results of the accident have called attention to these possibilities and the lessons of this accident should lead to much closer attention being paid to such problems in future with a view to minimizing the chances of disaster.

(5) As regards the provisons of safety catches, no action is called for as the conditions at Edgar's Shaft are in accordance with the best practice at other mining centres. Further opinions will, however, be obtained as to the advisability or otherwise of using special wooden runners in steel equipped shafts with a view to the employment of certain forms of safety catch which are applicable to wooden runners but not to steel guides.

MYSORE GEOLOGICAL DEPARTMENT,
Bangalore, 16th October 1914.

W. F. SMEETH,
Chief Inspector of Mines.

ENCLOSURE I.

Read—

The following report, dated the 27th September 1913, of the Committee appointed by Government in Proceedings (Geological) No. 580-7, dated the 29th August 1913, to enquire into the circumstances of the fatal accident due to the fall of a cage in Edgar's Shaft, Mysore Mine, on the 21st August 1913.

REPORT.

The following are the members of the Committee :—

Mr. Justice Wallace, I.C.S. (Chairman)
Dr. W. F. Smeeth, M.A., D.Sc., A.R.S.M., etc., Chief Inspector of Mines in Mysore
Mr. C. Srikanteswara Aiyar, B.A., B.L., Inspector-General of Police in Mysore
Mr. Guy. Ll. Taylor, A.M.I.M.M., Chief Engineer of the Ooregum Gold Mining Company
(Members)

At the first meeting of the Committee Mr. Justice Wallace was elected Chairman.

I.—Programme.

September 4th.—Committee assembled at the Mysore Mine and spent the afternoon inspecting the winding plant at Edgar's Shaft. The working of the engine, clutches, brakes, etc., was fully explained.

The Committee also inspected the cage which fell away and which had been taken to pieces underground and brought to surface piecemeal. The skip engine at Edgar's Shaft was also inspected while at work; the engine is fitted with similar clutches and brakes to the cage engine.

September 5th—The Committee met during the forenoon and afternoon and interviewed the following witnesses :—

Mr. G. A. Paterson, Chief Engineer, Mysore Mine.

Mr. W. Kendall, Assistant Engineer, Mysore Mine, in charge of the Edgar's Shaft Winding Plant.

J. Jenkins, Driver of the Winding Engine at the time of the accident.

John Richards, Timber Foreman, who was at the 3,220 plat in Edgar's Shaft when the cage fell.

Notes of the statements and replies of witnesses are given in the appendix hereto.

The portions of the broken link which caused the accident were examined and the opinions of Messrs. J. Richards and W. Phillips, Foremen Blacksmiths of the Mysore and Ooregum Mines, taken.

September 6th.—In the forenoon, the Committee met at the Inspector of Mines' Office and interviewed Mr. W. J. Clemo, Acting Chief Engineer, Champion Reef Mine, in regard to the clutch on the winding engine at Carmichael's Shaft.

The Committee then inspected the winding plant at Carmichael's Shaft and witnessed the operation of the clutch.

Subsequently, the Committee inspected a multiple tooth clutch at Bullen's Shaft, Ooregum Mine, and saw it operated.

In the afternoon, the Committee discussed the evidence and prepared a rough draft of their report which was subsequently completed and circulated for confirmation.

II. Brief Account of the Accident.

About 7 A.M. on the morning of the 21st August 1913, the south cage in Edgar's Shaft, Mysore Mine, fell from 100 feet below surface to the bottom of the shaft, a distance of 2,600 feet. The cage has two compartments one above the other in each

of which 25 men are permitted to travel. At the time of the accident there were altogether 42 persons in the cage, *viz.*, 6 Italians, 2 Eurasians and 34 Natives, all of whom appear to have been killed instantaneously when the cage reached the bottom of the shaft. When the cage fell away, at 100 feet from surface, it was on the downward trip and travelling at some 1,200 feet per minute.

2. Edgar's Shaft is a vertical circular shaft which was completed and equipped some two years ago. The cages run up and down on steel guides without safety catches.

3. There are two cages, one of which ascends as the other descends, each cage being suspended by a flat steel rope passing over a pulley at the top of the head-gear and led from thence into the engine room where it is coiled round a flat drum or reel twenty feet in diameter. Each reel is mounted on the main engine shaft, but is not rigidly fixed to the latter. While winding is going on the reel is secured to the main shaft by means of a clutch which in the present engine is in the form of a steel band, lined with wood, acting on a drum—very like a band brake. One end of this steel band is attached to a fixing on the shaft through an "adjusting link" for taking up wear and regulating the grip of the clutch band. The accident was due to the snapping of this link which released the clutch and left the reel, on which the winding rope is coiled, free to revolve on the shaft and therefore disconnected from the engine.

4. The link which snapped is in the form of a bolt 3⅜ inches in diameter and about two feet long, made of mild steel. The fracture was perfectly clean and fresh and showed no appearance of any flaw or old fracture.

5. Each reel is provided with a very powerful post brake for the purpose of controlling the rotation of the reel, whether the latter is clutched to the shaft or not under ordinary working conditions and the brakes are in constant use every day. At the moment when the link snapped and the south reel became declutched from the main engine shaft, the south cage, carrying 42 men, was 100 feet below surface and the north cage with 21 men in it was about 75 feet above the 2520 station (1,630 feet vertical), the former descending and the latter ascending. The engine driver (J. Jenkins) heard the snap of the link and without being able to recognize what had happened he immediately cut off steam and applied the two brakes. The promptness of this action is shown by the fact that the north cage was brought to rest 150 feet above its starting point (2520) so that it travelled only about 75 feet after the snap took place. In other words, after the snap was heard the engine driver cut off steam, applied the brakes and brought the north cage to rest within a space of a few seconds and the cage with its burden of 21 men remained suspended in the shaft for three hours or so until it was ascertained that it was safe to lower it again to the 2520 station. In this case, the weight of the cage, rope, etc., helped the brake to overcome the momentum of the moving masses.

6. In the case of the south cage which was descending, the whole work devolved upon the brake which failed to bring the reel and the cage to a standstill. The friction of the brake blocks on the brake drum of the reel was so great that the wooden brake blocks were charred and the engine room filled with smoke. The engine driver stuck to his post, though he could do nothing further, while the reel revolved in a cloud of smoke and after the cage had struck the bottom the rope continued to pay out until some 14 spare coils were unwound and finally the plate and bolts which attach the rope to the drum of the reel were torn off and disappeared through the window of the engine house.

III. Points Considered by the Committee.

The various points taken into consideration and the opinions of the Committee on each are recorded below.

1. *The Suitability of the Winding Plant for the Work to be done.*—On a technical matter of this character the Committee are not prepared to offer any critical opinion. Ample evidence has however been produced to show that the plant has been carefully designed by experts and the designs carried out by responsible firms. From Mr. Paterson's statement (Appendix (i)) it will be seen that the engine was put in in 1904 and altered in 1911 when regular winding of men commenced.

In regard to the alterations made in 1911, when the present reels, brakes and clutches were put in, the whole question of the requirements for the shaft and winding plant was decided upon after exhaustive investigation by a Committee of Engineers and also by a Committee of Superintendents of the Mines.

In connection with the accident, three items call for special attention, *viz.*, (*a*) the clutch, (*b*) the brakes and (*c*) the absence of safety catches from the cages. The opinion of the Committee on these is as follows:—

(*a*) *The Clutch.*—This is a device for securing the reel to the main engine shaft when winding is going on. The particular clutch used is of the friction-band type and was made by the Wellman Seaver Head Company of London.

It is apparently of a well known standard design in use on such winding engines in many parts of the world and was supplied by the makers of the engine.

The clutch has been in constant use for the past two years and has given no trouble.

The link which fractured and caused the accident is in the form of a threaded steel bolt 3⅜ inches in diameter and about 2 feet long. Mr. Paterson estimates the breaking strength of the link at about 230 tons and that of the clutch band to which the link is attached at 187 tons while the strain put upon these when the clutch is operated is estimated at between 58 and 59 tons. From these figures; the design appears to provide a large margin of safety and the Committee are unable to say why the link gave way. From the appearance of the fracture and from the opinions expressed by Engineers and Blacksmiths who examined it, the Committee are satisfied that there was no flaw or old crack which should have been detected and they are unable to say positively that the breaking of the link should have been foreseen or regarded as an event likely to occur.

(*b*) *The Brakes.*—The brakes, which are designed to bring the reel to rest and hold the cage at the various stopping places in the shaft under normal working conditions, are of the post brake type usually employed for large winding engines. The evidence before the Committee shows that they have proved satisfactory and effective hitherto for the work demanded of them.

The fact that the brakes on the south reel, which in the opinion of the Committee were promptly applied [see Section 5 (c)], were not sufficiently powerful to stop the descending cage after the reel had become declutched from the main engine shaft may be regarded as evidence that the brakes are not sufficiently powerful for abnormal emergencies. The Committee are unable to express any opinion on the technical question whether they might have been made sufficiently powerful to stop the descending cage, or whether it is possible to make them so with safety and are unable to assign any blame or responsibility to any one for the failure of the brakes to bring the cage to rest.

(*c*) *Safety Catches.*—These are devices intended to hold up the cage in the event of the rope breaking. When the shaft was equipped for winding men (in 1911), it was decided that no suitable or satisfactory catches could be obtained for working on the steel guides of this shaft and with this decision the Chief Inspector of Mines concurred. The Committee are satisfied that the absence of safety catches did not in any way contribute to the accident and that the provision of safety catches would not have prevented the falling of the cage down the shaft as the rope did not break.

2. *Condition of the Machinery at the Time of the Accident.*—The machinery appears to have been in good order and working properly up to the time of the accident.

3. *Inspections by Officers of the Mine.*—The mining rules provide that the brakes, rope, shackle and all other parts of the winding gear shall be examined once in every 24 hours, and the external parts of the winding engine once a week, by a competent person specially appointed for the purpose.

Mr. W. Kendall, Assistant Engineer, is the person appointed to carry out these inspections of the Edgar's Shaft winding plant and he testified to having carried out these duties regularly, and produced the book in which the result of every such inspection is recorded under his signature.

In addition to this, Mr. Paterson, the Chief Engineer of the Mine, informed the Committee that he paid frequent visits to the engine room and made an official inspection of the plant once a week.

According to these officers, the machinery was in good working order.

4. *Government Inspection.*—The mining rules, which have lately been revised, provide that before any winding plant is used for raising and lowering persons the permission of an Inspector of Mines must be obtained; such permission being given only after the Inspector has satisfied himself that the provisions of the rules have been duly and reasonably complied with and that the condition of the plant, etc., is satisfactory. Mr. L. H. Beckwith, Officiating Inspector of Mines, produced the necessary papers to show that the required permission had been granted by Mr. R. Bocquet, Officiating Chief Inspector of Mines, in 1911 when the equipment of the shaft for raising and lowering persons was completed.

Dr. W. F. Smeeth, Chief Inspector of Mines, informed the Committee that he had inspected this plant on several occasions and had been perfectly satisfied with its condition and performance. He pointed out however that such inspections are essentially of a purely formal character as the Inspectors of Mines have neither the time nor the qualifications for conducting critical examinations and tests of the large mass of high class machinery now in use in the mines. Such examinations and tests demand the services of specially qualified Inspectors of Machinery and there are no such officers in Mysore. At present, these matters are, and must be, left to the Chief Engineers of the Mines and the experts of the firms who supply the plant.

From the foregoing the Committee are of opinion that the inspections required by the rules have been duly carried out, but that those carried out by the present official staff are of less value and utility than they might be owing to the lack of properly qualified and experienced machinery experts.

5. *Action of the Engine Driver at the Time of the Accident.*—The Engine Driver, J. Jenkins, bears an excellent character over a long period of service of which 16 years were spent at Collieries in South Wales and 9 years on the present engine at Edgar's Shaft. There can be no question as to his experience and competency.

The account given by him and recorded in the appendix as to what happened in the engine room is amply supported by circumstantial evidence. The chief points are the following:—

(*a*) The descending cage had gone down only a short distance—about 100 feet from surface—at the moment the link fractured.

(*b*) At that point the cage cannot have been travelling very fast. The driver's estimate of 1,200 feet per minute is a reasonable one and is about half the usual maximum speed of winding in this shaft.

(*c*) On hearing the noise caused by the fracture of the link, the driver shut off steam and put on the brakes with great promptness. This is shown by the position of the ascending cage which was brought to rest within 150 feet of its starting point and can have travelled only about 75 feet after the fracture occurred.

(*d*) The driver is supposed to test the brakes every day and adjust them when necessary. The brake on the north reel brought the ascending cage to rest and held it securely suspended in the shaft for some hours.

The brake on the south reel gripped sufficiently hard to char the wooden brake blocks and produce a large amount of smoke although the retarding effect was insufficient to bring the descending cage to rest. The facts that the cage was not severely crumpled after falling 2,600 feet and that the timber-foreman, John Richards, who was at a station in the shaft 2,100 feet from surface, does not appear to have been seriously impressed with the speed at which the falling cage passed him go to show that the cage was by no means falling freely and that the brakes were effecting a considerable retardation.

It is probable therefore that the brakes were in good working adjustment, but the Committee are not prepared to say whether the adjustment might or might not have been improved to an extent which would have brought the cage to a standstill.

In the opinion of the Committee, the evidence all tends to show that the brakes were in proper adjustment and were promptly applied and no blame whatever can be attached to the driver on account of the fact that they were not sufficiently powerful to completely reduce the velocity and bring the cage to rest.

IV. Conclusions.

To summarize the report, the findings of the Committee are as follows :—

1. The machinery was carefully designed and constructed by experienced and responsible persons and has been kept in good working order.

2. The Committee are unable to give any explanation of the fracture of the link and find no reason to consider that it should have been anticipated. This, however, is a point which demands, and should receive, full technical enquiry.

3. The Committee are of opinion that no blame whatever attaches to the Engine Driver or other officials of the Mine. The Engine Driver acted with commendable promptness and thereby saved the ascending cage and its occupants from disaster.

4. The fracture of the link of this clutch and the facts disclosed before the Committee as to the failure of portions of other clutches of the same type impress on the Committee the necessity for closer official inspection of the machinery on the mines on which so many lives depend. They note that there is at present no official Inspector of Machinery with the experience and qualifications which would justify him in imposing advice on highly technical matters on Engineers of the ability and experience of those employed by the Mines and justify Government in putting on him the responsibility for the safety of the large working population of the mines and for the prevention, as far as experience and foresight can provide, of such accidents as the one under enquiry.

The Committee, without in any way questioning the experience or ability of the Engineers of the Mines, are of opinion that it would be advantageous to Government, to the Engineers of the Mining Companies and to the working population of the Mines, to have more expert official supervision of machinery than obtains at present.

The continuity of experience and co-ordination of results which would be secured by a properly qualified and responsible Government expert, whose time was primarily devoted to questions of safety, are probably not being sufficiently obtained under existing arrangements according to which such questions have to be left, very largely, to the discretion of the Engineers of individual mines.

APPENDIX.

Notes of statements and replies made by persons interviewed by the Committee.

(1) Mr. G. A. Paterson, Chief Engineer of the Mysore Mine.

The following details of the engine, cages and attachments were furnished:—

	Feet.
Depth of shaft (vertical)	2,700
Diameter of shaft (circular)	18 inside
Vertical depth 2520 station	1,630
,, ,, 3226 ,, ...	2,108
,, ,, No. 7 ,, ...	2,587
,, ,, No. 8 ,, ...	2,661
Bottom	2,700
Size of reels—diameter	20 outside 8 inside
Size of ropes (flat)	$4\frac{3}{4}'' \times \frac{7}{8}''$
Makers of ropes	Messrs. T. & W. Smith, Newcastle-on-Tyne.
Breaking strain of ropes	136 tons.
Weight of cage, rope and attachments	$13\frac{1}{2}$ tons.
Weight on end of the rope when accident happened ...	About $7\frac{1}{2}$ tons.
Number of men sent down in 24 hours	,, 3,000 men.
Number of trips in 24 hours	,, 130.
Date on which engines were started	November 1904.
Date of alterations made to engines, two reels attached to them and regular working	May 30th, 1911.
Time engines have worked since alterations	2 years and 3 months.
Safety catches	See letter from Sandycroft, Ltd. None known to be reliable.
Weight of 50 coolies	About 5,600 lbs.
Name of makers of engines who also supplied reels, brakes, etc.	Messrs. Thornewill and Warham, Burton-on-Trent.
Steam pressure at boilers	About 120 lbs. per square inch.
Size of engines	High Pressure Cylinder 30″ diameter 6 feet stroke.
(Only high pressure cylinders in use at present.)	
Nominal horse power of engines	About 800 H. P.
Maximum rope speed	2,000 feet per minute.
Speed of cage when clutch broke	1,200 feet per minute.

A bell rings when the ascending cage is 200 feet from surface when the Engines are slowed up.

Drivers have worked the Engine for 9 years and are reliable.

This is the first accident that has happened since the engines started working on May 30th, 1911.

New ropes were put on March 3rd, 1913.

Engines were overhauled in March 1913.

Mr. W. Kendall is in charge of the Engines and visits them daily; a daily record book is kept for this purpose.

I have been Chief Engineer of the Mysore Mine for $6\frac{1}{2}$ years, previous to which I was Chief Engineer of the Ooregum Mine for $8\frac{1}{2}$ years and before that Chief Engineer of the Mysore Reefs for $11\frac{1}{2}$ years.

This Engine was put in in 1904, and was used for sinking the shaft with a single 24 feet drum.

When the shaft was completed it was necessary to put on double drums for the two cages and this was completed in 1911.

The responsibility for design rests partly with the Chief Engineer and partly with the makers.

The details as to depth, weight to be hoisted, speed of hoisting and type of machine to be used rest primarily with the Chief Engineer. The responsibility for design, efficiency and strength rests with the makers.

The alterations completed in 1911 were made while I was Chief Engineer and were decided upon after special investigations by a Committee of Engineers and by a Committee of Superintendents of the Mines. (The reports of these Committees were submitted for information.)

The clutches for the reels are of a friction type made by Messrs. Wellman Seaver Head & Co., London, and were supplied by the makers of the Engine.

I selected this particular type of clutch as I considered it particularly suitable for the work. I had no previous experience of it, but it is a well known make in use in many parts of the world for winding engines. The clutches have been in use for over two years and have been quite satisfactory. I have never known one of these links to break. The link appears to be amply strong enough. It is made of steel, 3⅜" in diameter, with a screw thread which reduces the diameter of the metal to 3¼". The fracture was quite clean and showed no signs of any flaw or old crack. I cannot say why it broke.

It is considerably stronger than the band of the clutch to which it is attached.

The breaking strain of the link is about 230 tons, that of the clutch band about 187 tons and the tension put upon the band and link when the clutch is put in is about 58·5 tons.

Similar clutches are in use on the skip engine at the same shaft. Shortly after starting, the band of one of these clutches cracked and the band was replaced since when we have had no trouble.

I do not know of any type of clutch which has not failed at some time or other. Naturally, I am not so satisfied with the present clutch as I was before the accident, but I do not consider it necessary to discard the clutch nor do I know of one to replace it which could be guaranteed never to fail.

Before putting the engine to work again the parts will be strengthened and other proposals for minimizing risk are under consideration.

The brakes on the reels are of the usual 'post' type and were supplied by the makers of the Engine. They have proved sufficient for all ordinary work. I do not know if any brake would have held the descending cage. The brakes were in good order and were put on immediately and acted properly. The friction on the brake of the south reel was sufficient to char the wooden brake blocks and fill the engine room with smoke.

The cage was not descending very rapidly; only about half the maximum pace at which winding is permitted which is about 2,000 feet per minute. This is not a high speed for modern winding engines.

There are no safety catches on the cages. No safety catch would have been of any use in this accident as the rope did not break.

The question of safety catches was most carefully considered when the shaft was equipped and it was decided that nothing satisfactory or reliable could be obtained.

The cages work on steel guides in the shaft.

The question of safety catches is still engaging attention and if a satisfactory device was forthcoming we should be very glad to put it in.

The Engine and all parts of the winding gear are inspected every day by Mr. Kendall, Assistant Engineer. I myself visit the engine room frequently and make an official inspection once a week.

Plans of the reels, brakes and clutches with their operating mechanism were submitted for inspection of the Committee.

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(2) Mr. W. Kendall, Assistant Engineer of the Mysore Mine.

I have been an Engineer on this mine for the past 11 years. I was engaged on the erection of this engine in 1904. The clutches and the brakes have been working quite satisfactorily.

The adjusting link which broke was adjusted on August 2nd, about three weeks before the accident. I inspect this engine and all the winding gear every day. A record of every inspection is kept in a book provided for the purpose. (Book produced before the Committee and examined.)

The brakes are taken up regularly by the Engine Driver, as required, usually every 1 to 4 days.

I arrived in the engine room ¼ of an hour after the accident. There was smoke in the room and a good deal of charcoal on the floor from the charring of the brake on the south reel. I cannot say if the brake ought to hold a runaway cage; I doubt if it would do so if the cage was travelling fast.

It might be advisable to have two brakes on each reel—one to be used as an emergency brake only. I think the post brake is the best type.

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(3) J. Jenkins, Driver, Edgar's Shaft Winding Engine.

I have had 9 years' experience on this engine.

Before that I had 16 years' experience on Colliery engines in the Ronda valley, South Wales, of which 11 were on hauling engines and 5 on winding engines.

On the day of the accident, I took over the engine at 7 A. M. and made two trips to the 3,226 level. I then unclutched the south reel and raised the north cage to the 2,520 level and put in clutch again, eased the brakes and tested grip of the clutch. I then started lowering a cage of men and when the south cage had gone down about 100 feet I heard a noise. I did not know what caused the noise but supposed it was due to the breaking of the link on the south clutch. I immediately cut off steam and applied the brakes full. The brakes are worked by two levers in front of me and if they are thrown forward the steam is released from the brake cylinders and allows weights to act on a series of levers which force on the brakes.

The amount of pressure on the brakes depends on the weights and I cannot increase the maximum amount of it.

When I put the hand levers forward the brakes acted at once and the north reel came to rest within one revolution and was held there by the brake. The south reel continued to revolve as the cage went down the shaft and the room was quickly filled with smoke from the friction of the brake blocks on it.

The reel continued to revolve until all the rope was unwound, the end of the rope being torn away from its attachment to the reel.

The brakes have been satisfactory and were in perfect order at the time. I always test the brakes every morning before starting work and if necessary adjust them.

The maximum speed of driving is between 50 and 60 revolutions a minute and at the time of the breakage she was going about 25 revolutions.

In the South Wales, men and coal are wound by the same engine and the speed of winding is often considerably greater than in Mysore.

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(4) John Richards, Timber Foreman, Mysore Mine.

I was at the 3,226 plat (about 2,100 feet vertical) in Edgar's Shaft at the time of the accident.

I heard the cage coming down and looked round. The cage passed the plat quietly but very quickly. There were no lights in it and no sound from it.

It was travelling very fast, faster than when winding is going on, but I do not know that I should have been struck with the speed if I did not know that the cage should not come below 2,520 plat and that consequently something must have happened.

It was quite an appreciable time before I heard the noise of the cage striking on the gate at the 7th level 500 feet below me, but I could not say how long.

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(5) Mr. W. J. Clemo, Acting Chief Engineer, Champion Reef Mine.

The winding engine at Carmichael's shaft, Champion Reef, is fitted with Wellman Seaver-Morgan friction clutches similar to those at Edgar's Shaft, Mysore. They have been in use 5½ years. The shaft is an incline shaft about 4,600 feet deep on the underlie which averages about 62°.

Between 4 and 5 years ago, the short arm of the lever which tightens the clutch band on the north drum broke owing to blowholes in the casting.

As far as I can remember the north skip was at surface at the time and the brakes were on the south drum but not on the north drum. The engine driver noticed the north drum revolving and immediately put on the brake which stopped the skip within 200 feet from surface. After that the levers of both clutches were replaced by levers of forged steel and have given no trouble since.

About 4 years ago, the eye plate bolted to the end of the clutch band on the south drum was found to be cracked on putting in the clutch and had to be replaced.

Two days ago, a similar crack was detected in the eye-plate on the north drum and the clutch has been put out of commission pending renewal.

I like the clutch and it is very suitable for this shaft where there are so many levels to be hauled from.

I have known a case of a multiple tooth clutch failing owing to the teeth being sheared off.

No. 1407, dated Bangalore, 13th December 1913.

Order thereon.—The Committee are of opinion that the accident is not traceable to negligence on the part of the mining employees concerned. The machinery appears to have been carefully designed and well looked after and, so far as could be ascertained by reasonably careful supervision, in good working order.

2. The fact that the brakes failed to arrest the cage and avert an accident would suggest either that they were not promptly applied or that they were not sufficiently powerful or effective to cope with an emergency of this character. In the opinion of the Committee, the Engine Driver acted with commendable promptness and did all that lay in his power to avert a catastrophe and in view of the circumstances under which the accident took place and the evidence recorded by the Committee, Government agree with this finding.

3. Having regard to the serious nature of the accident and the responsibilities involved in the winding of large numbers of men in these cages, Government recognise the necessity for every possible precaution being taken in regard to the safety of the appliances employed and agree with the Committee that a further technical enquiry is desirable as to the circumstances under which the accident took place. Such an enquiry has already been proposed by the Chief Inspector of Mines in his preliminary report, dated 23rd August 1913, and this enquiry is now in progress. The Chief Inspector of Mines is requested to submit a full report of the technical enquiry after any necessary consultation with special authorities on the technical issues involved. The enquiry should deal with the following questions:—

(1) The causes of the fracture of the adjusting link and whether the fracture was due to defective design or material or to improper use.

(2) The suitability of the clutch as a whole, of which the fractured link formed a part, for the purposes for which it is employed in connection with the winding of men in shafts.

(3) The efficiency of the brakes fitted to the Engine and whether it is desirable or possible to make them more powerful or more effective.

(4) Whether it is not possible to introduce safety catches for the cages in such shafts.

(5) What further precautions may be taken to minimize the possibility of such accidents.

4. The Committee incidentally observe that, though the Chief Engineers of the Mines are experts in machinery, the appointment of an official Inspector of Machinery will be of advantage; but as far as the present enquiry has gone, it seems that such an Inspector could have done very little in either preventing the fracture of the link or arresting the uncontrolled descent of the cage. Government will however be prepared to examine the question further in the light of such conclusions as may be arrived at during the technical enquiry.

5. The thanks of Government will be conveyed to the members of the Committee for their report.

W. F. SMEETH,
Secretary to Government,
Geological Department.

To—The Chief Inspector of Mines in Mysore.